Hermean magnetospheric structure shape dynamics

David Parunakian (1), Igor Alexeev (1), Elena Belenkaya (1), Valery Petrov (3), and Maxim Khodachenko (2)
(1) Moscow State University, Skobeltsyn Institute of Nuclear Physics, Moscow, Russian Federation (parunakian@gmail.com),
(2) Institut für Weltraumforschung, Österreichische Akademie der Wissenschaften, Graz, Austria, (3) Pushkov Institute of
Terrestrial Magnetism, the Ionosphere and Radio Wave Propagation, Russian Academy of Sciences

In this work we investigate the dynamic nature of Mercury’s magnetosphere based on fitting parameters of the
Paraboloid magnetosphere model (PMM) to magnetic field measurements obtained by the MESSENGER mission
during each orbit separately. Earlier work has allowed us to perform data preprocessing in order to remove a num-
ber of systematic effects that would negatively impact the performance of our large-scale modelling effort, such as
changes in the aberration angle of Mercury’s magnetosphere induced by the solar wind that varies strongly due to
the high eccentricity of Mercury’s orbit; this is important to acknowledge as the data set we process spans over 1
Hermean year.

We take a number of measures in order to reduce the chance or completely avoid the optimization algorithm
converging to local minima. First, we run optimization procedure multiple times for each MESSENGER orbit
and choose initial variable values randomly in physically meaningful ranges. After running the optimization al-
gorithm the desired number of times, we choose the set of parameters that produces the lowest rms error relative
to the observations. Second, we assume that in cases where the magnetosphere of Mercury was not affected with
any interplanetary medium disturbances (such as coronal mass ejections) paraboloid model parameters describing
magnetic field measurements during consequent orbits should change smoothly and lightly; thus, running opti-
mization of the (i+1)-th orbit from initial parameter values produced during the simulation of the (i)-th orbit, and
then running optimization of the (i)-th orbit again from initial parameter values produced during the simulation
of the (i+1)-th orbit should converge to the same values as before. Finally, we perform k-means clustering on
the space of paraboloid model parameters in order to identify common states of the magnetosphere described by
similar parameter values.